



# GEO-SEQ PROJECT RESULTS

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**GEO - SEQ**

# Introduction

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- Initiated in 2000, part of DOE FE-NETL Sequestration Program portfolio
- GEO-SEQ has developed new methods and approaches for reducing the costs and risks of geologic sequestration
  - EOR, EGR
  - Co-optimize separation and sequestration
  - Performance assessment methods
  - Monitoring technology
  - Capacity assessment
- Current focus-field testing and validation of methods at the Texas Frio Brine Formation pilot
- GEO-SEQ PARTICIPANTS
  - Three National Laboratories (LBNL, LLNL, ORNL)
  - Stanford University
  - Texas Bureau of Economic Geology
  - Alberta Research Council
  - Four industry partners: Bd, ChevronTexaco, EnCana, Statoil



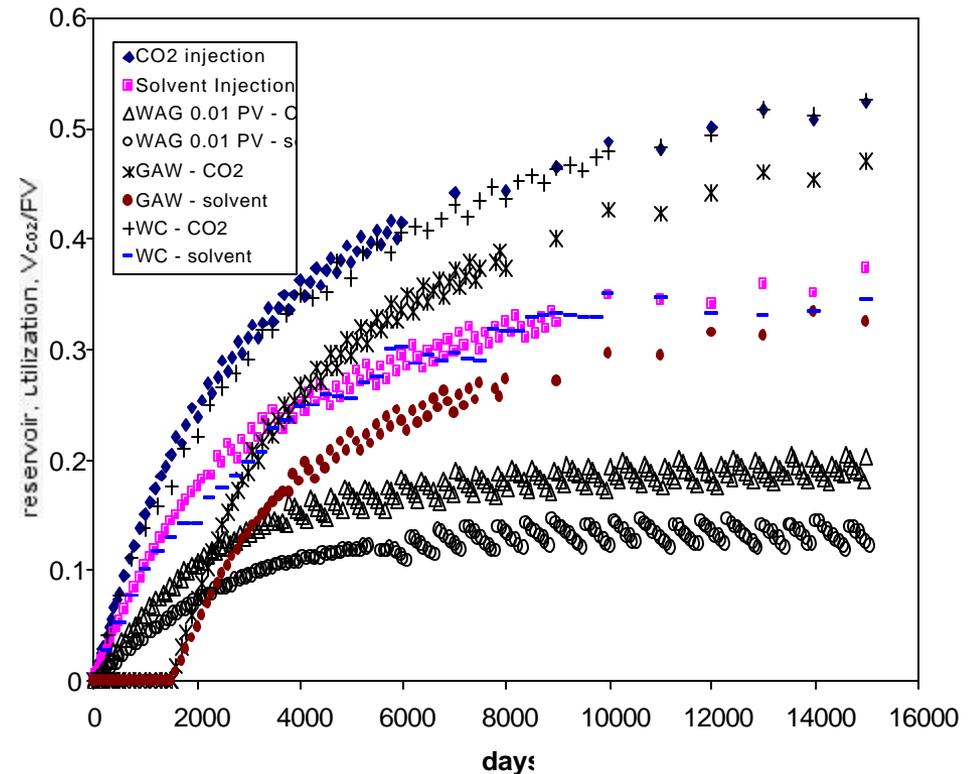
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**GEO - SEQ**

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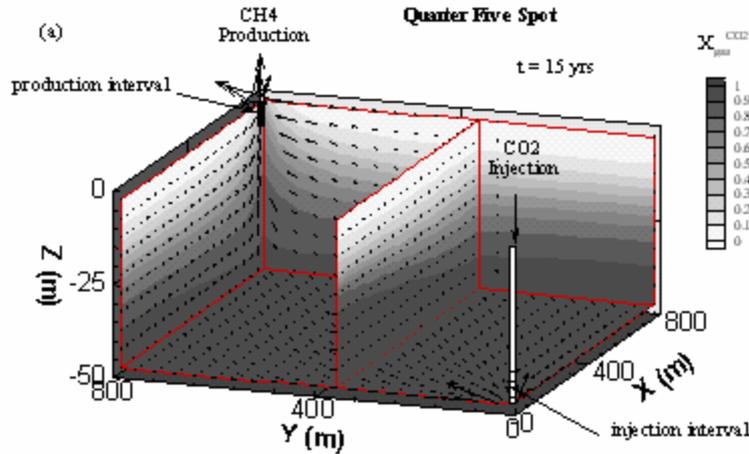
# New Methods Will Optimize Sequestration and EOR

- Active well control based on producing gas/oil ratio can limit gas cycling, maximize CO<sub>2</sub> storage, maintain oil recovery
- New streamline-based simulator facilitates required reservoir engineering analyses



(a)  
Comparison of reservoir utilization for various CO<sub>2</sub> EOR schemes

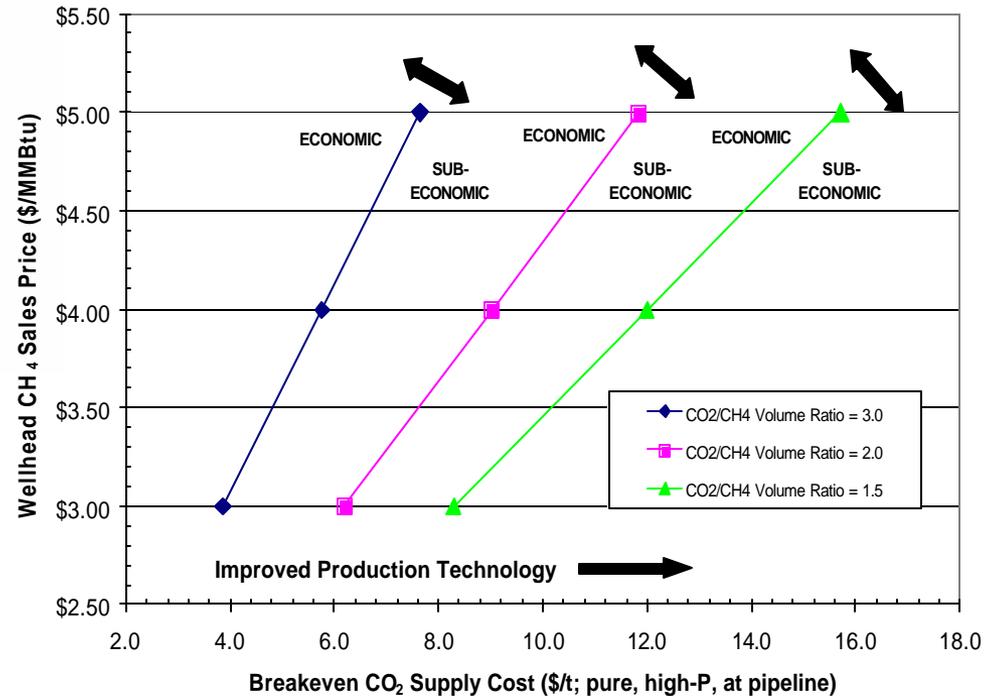
# Carbon Sequestration With Enhanced Gas Recover (CSEGR) is an Option



Production strategies can limit mixing and delay CO<sub>2</sub> breakthrough

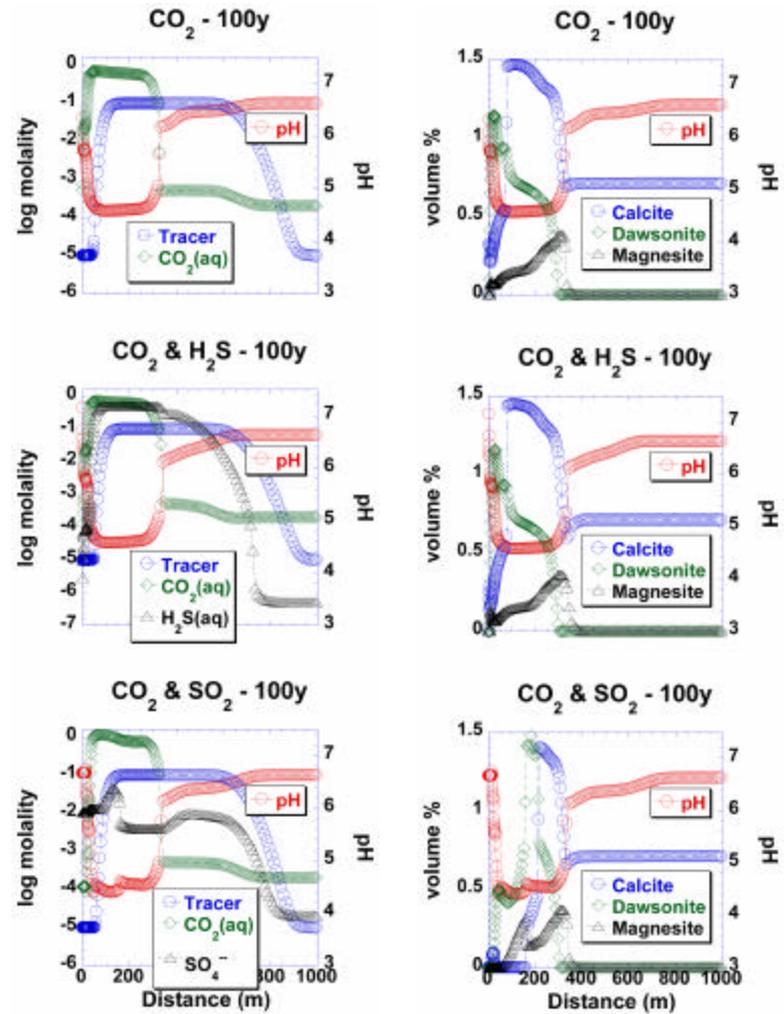
- CO<sub>2</sub> could be effective cushion gas for conversion of CSEGR projects to CH<sub>4</sub> storage

Economic Analysis of CSEGR at California Depleting Gas Field

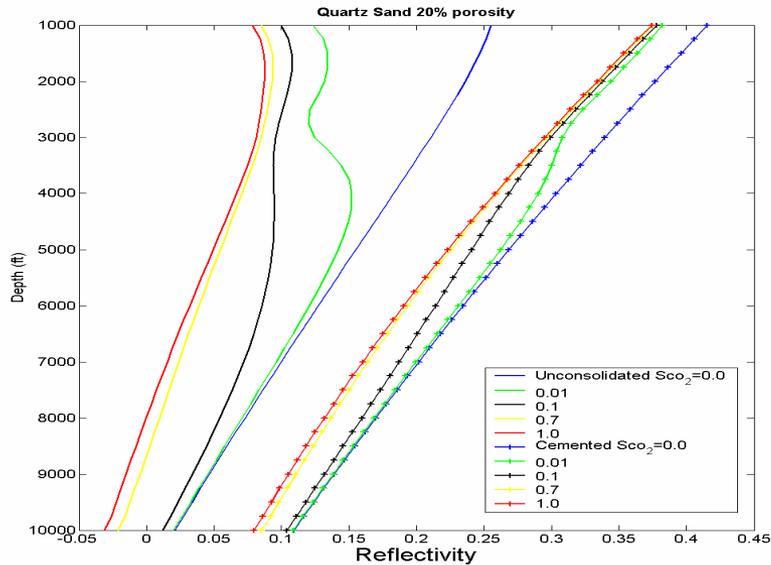


# Modeling Provides Basis for Assessment of Storage of Impure CO<sub>2</sub>

- Equilibrium thermodynamics, chemical/kinetics and reactive transport simulations
- Generic feldspathic and carbonate reservoir, Texas Gulf Coast sediments
- Large amounts of H<sub>2</sub>S not problematic; only minor amounts of SO<sub>2</sub> could be tolerated; NO<sub>2</sub> intermediate
- Experimental work to validate mineral growth needed

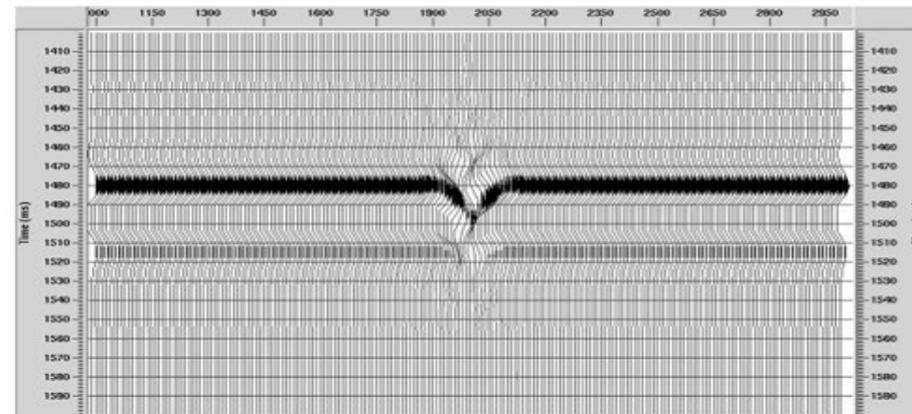
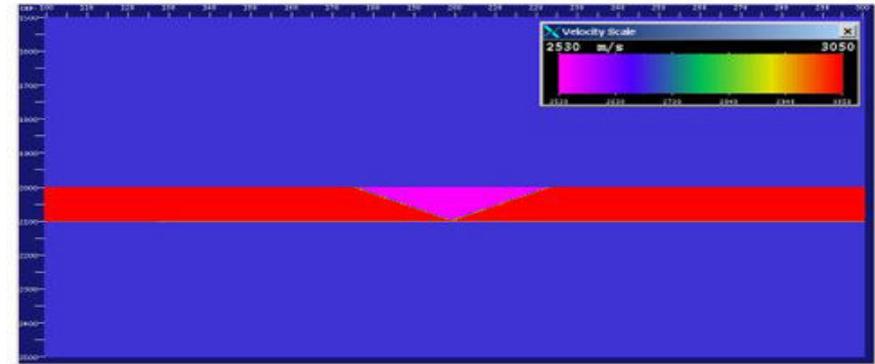


# Sensitivity, Coverage, Cost, Make 3-D Seismic a Key MMV Technique



Reflectivity of  $CO_2$  versus depth, based on Texas Gulf Coast sediments

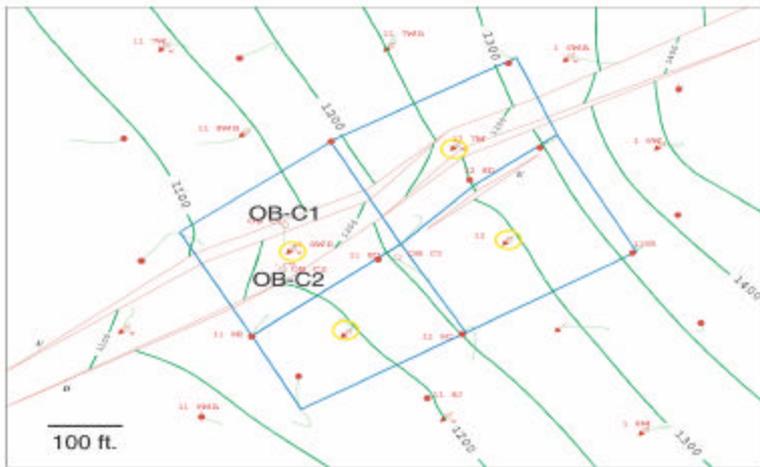
- Volume of  $CO_2$  equal to emissions of 1000 MW coal-fired plant for 1 day should be detectable
- 3-D monitoring costs: Few cents/ton



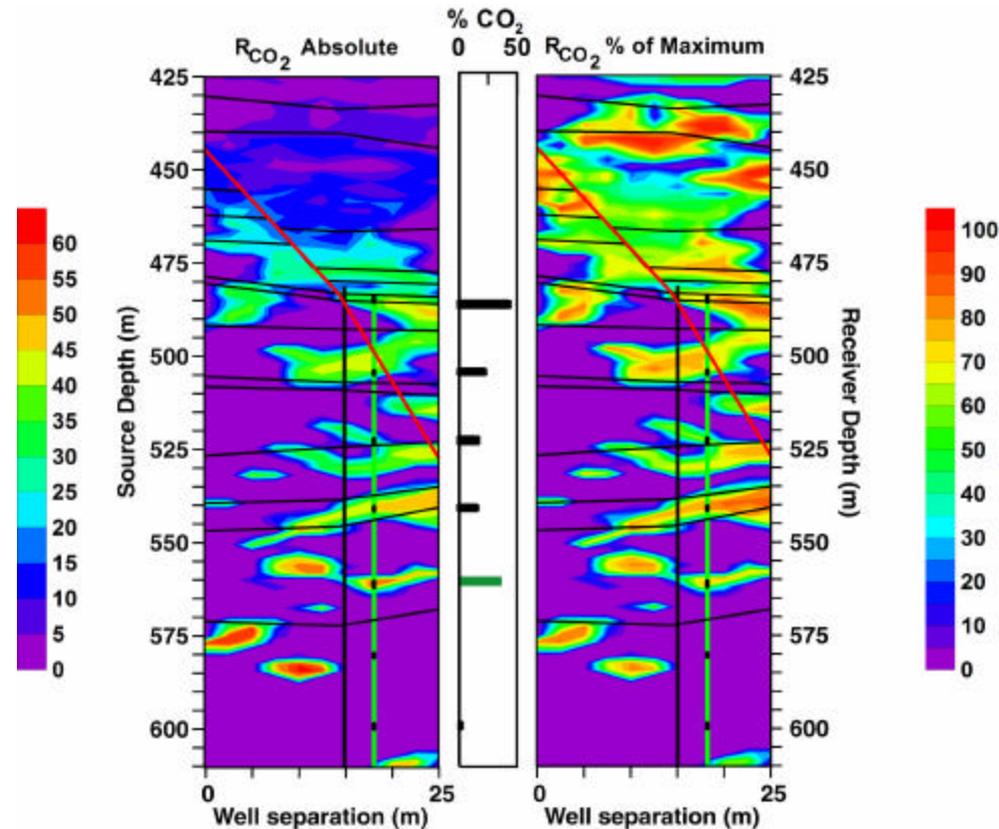
Modeled reflections from  $CO_2$  wedge in a sand layer

# Crosswell Techniques Provide a Quantitative, High Resolution Image of CO<sub>2</sub>

- Combining seismic and electrical (EM) methods is key for quantitative imaging of CO<sub>2</sub> saturation in oil reservoirs
- Rock-physics models derived from wireline logs

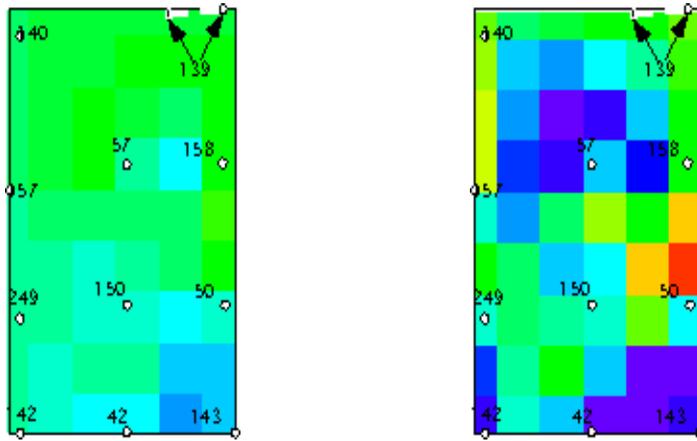


Plan view of Lost Hills Pilot

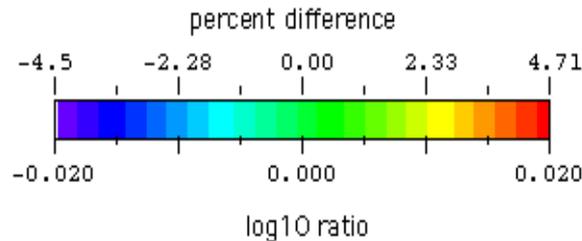


Time lapse image of CO<sub>2</sub>/oil ratio between wells at Lost Hills pilot

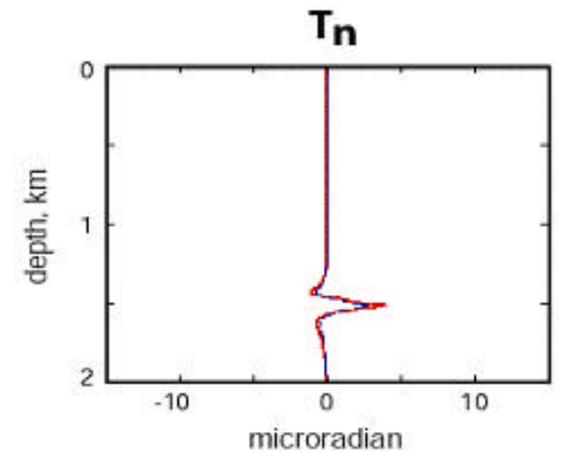
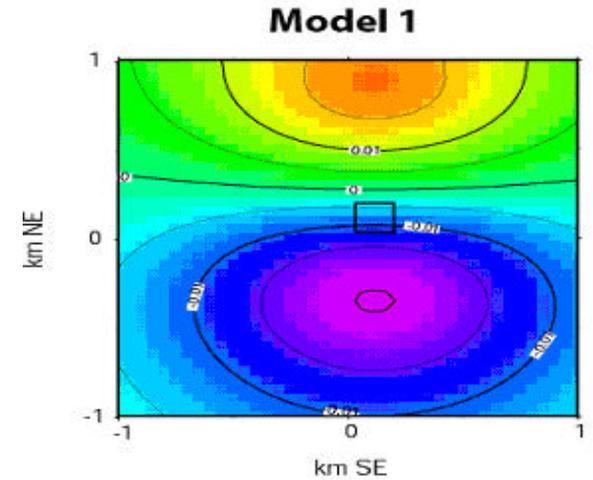
# Low Resolution, Low Cost, Non-Seismic Geophysical Techniques Have Potential



May 16 to Sept. 11      May 16 to Dec. 5200%



Time-lapse casing ERT from  
Vacuum Field, New Mexico

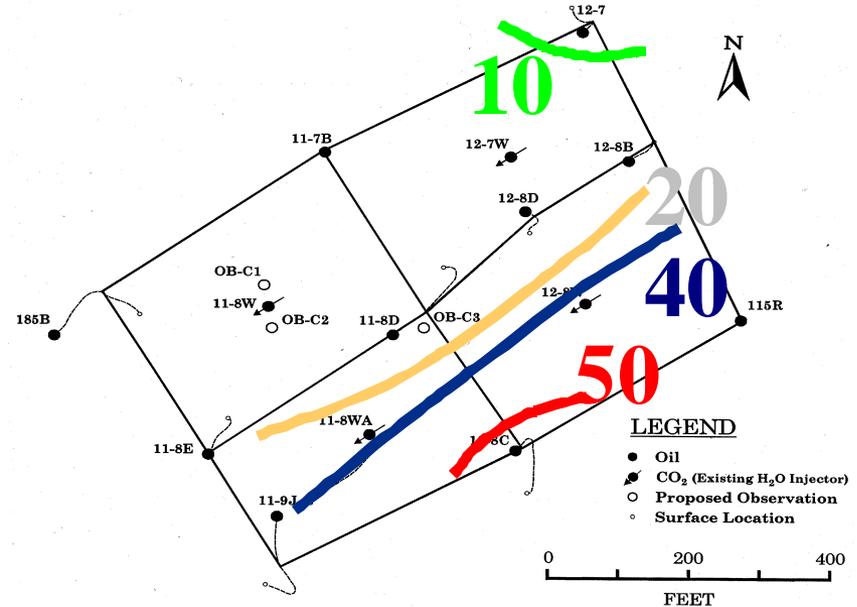


Numerical simulation of surface and  
downhole tilt profiles, Frio Pilot Model

# Natural and Introduced Tracers Provide Information on Reservoir Processes



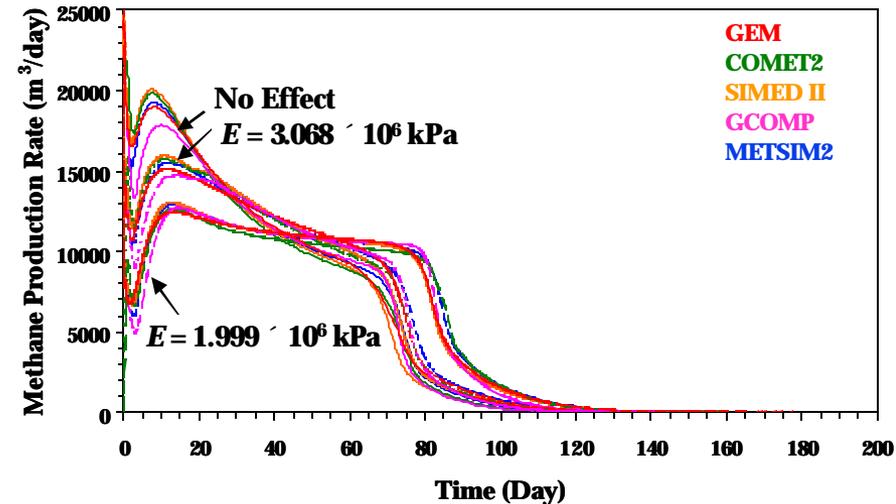
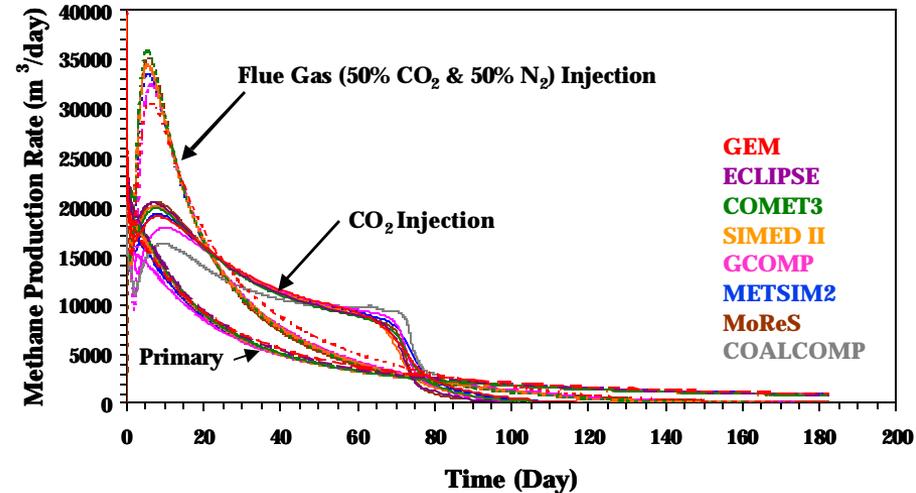
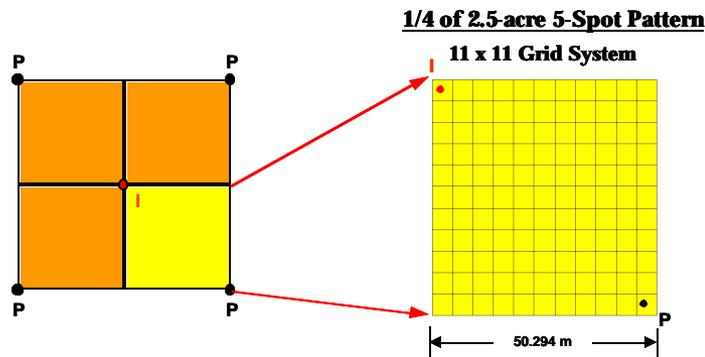
Flow system for assessing interactions of gas tracers with reservoir materials



Contours of %CO<sub>2</sub> injectate in Lost Hills pilot test

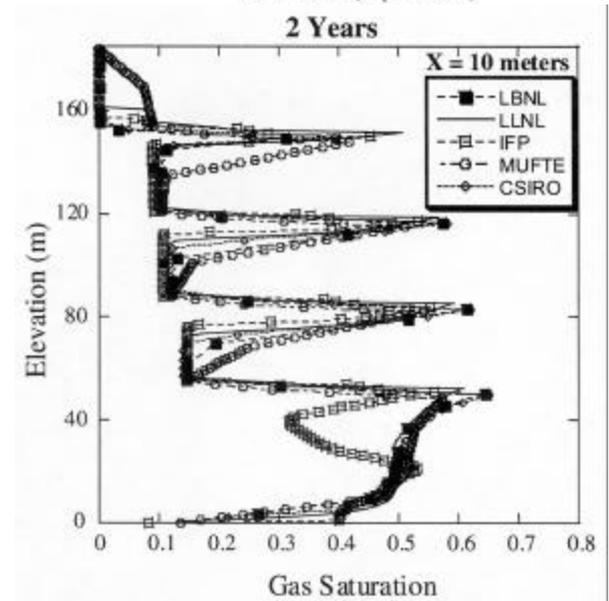
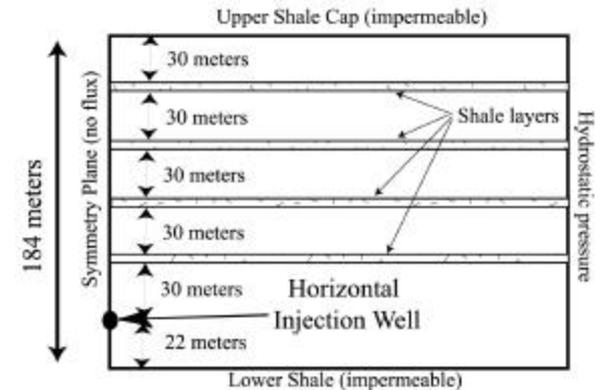
# Coalbed Methane Simulators Enhanced by Comparison Study

- Eight participating organizations, five countries
- Test problems involving physical processes of increasing complexity
- Generally good agreement between simulators
- Need work on geomechanical swell/shrink and mixed diffusion/adsorption



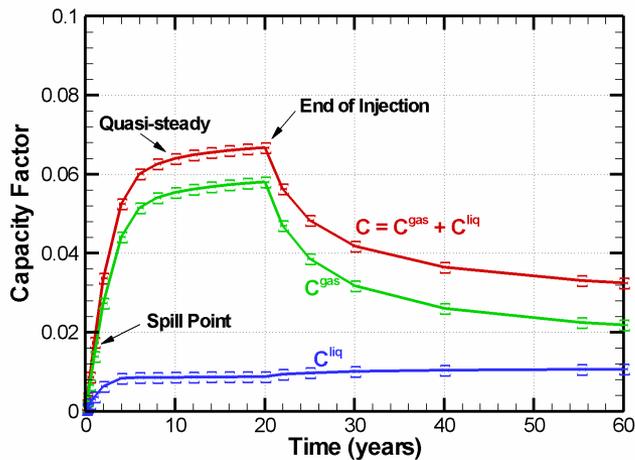
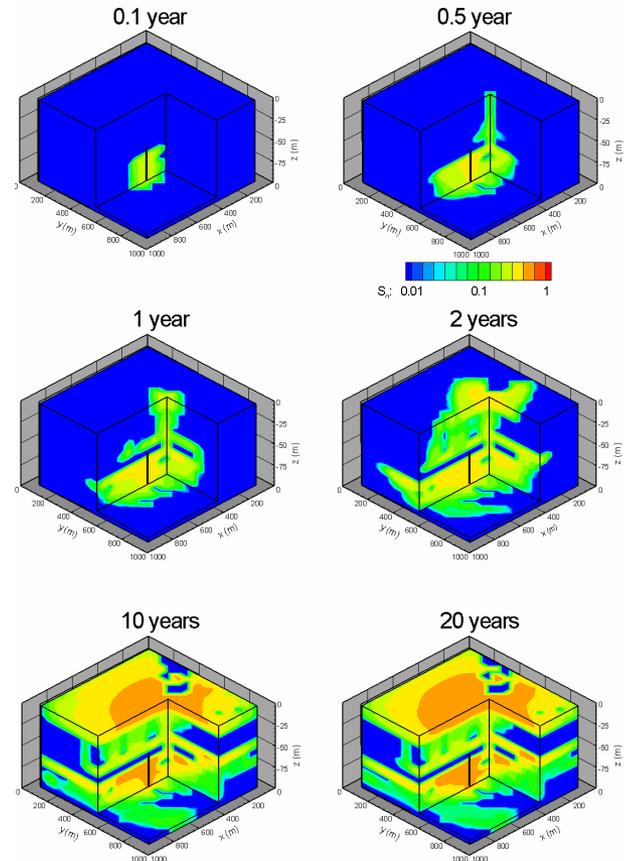
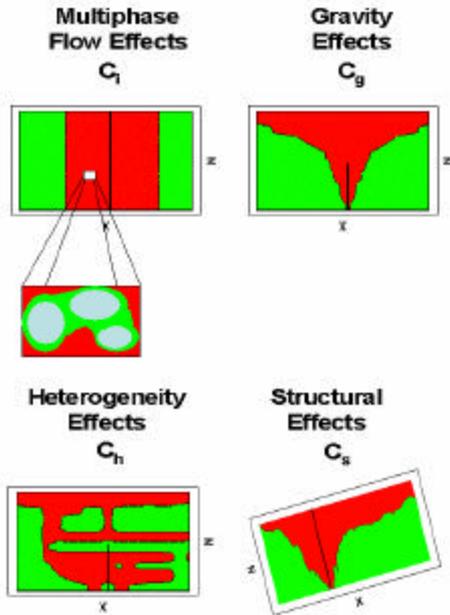
# Simulators for Oil, Gas, and Brine Formation Sequestration Benchmarked in Intercomparison Study

- Eight test problems involving hydrologic, geochemical, and geomechanical processes
- Ten organizations, six countries
- Important flow and transport processes well simulated
- Most discrepancies relate to fluid property descriptions
- Hydro-mechanical modeling capabilities need strengthening



Code intercomparison results, Test problem 7, Patterned after Sleipner Vest CO<sub>2</sub> project

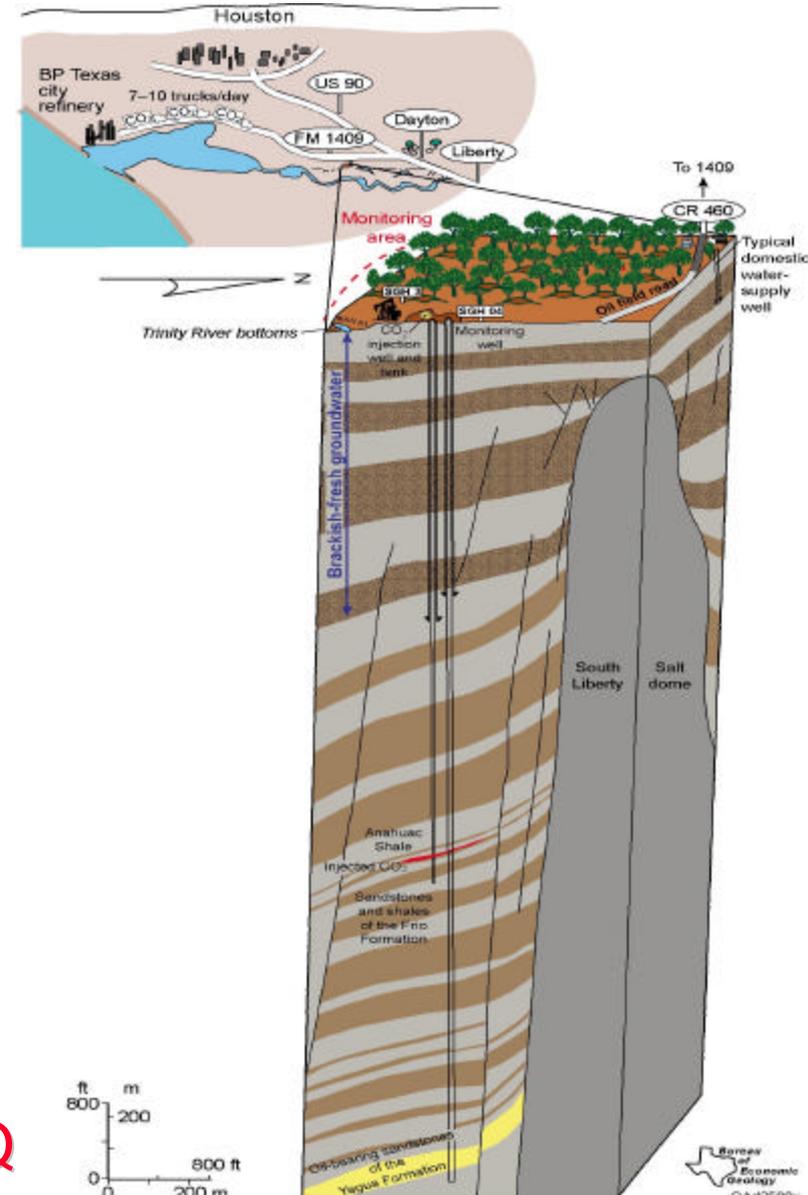
# Parameters Needed for Estimating Storage Capacity Have been Identified



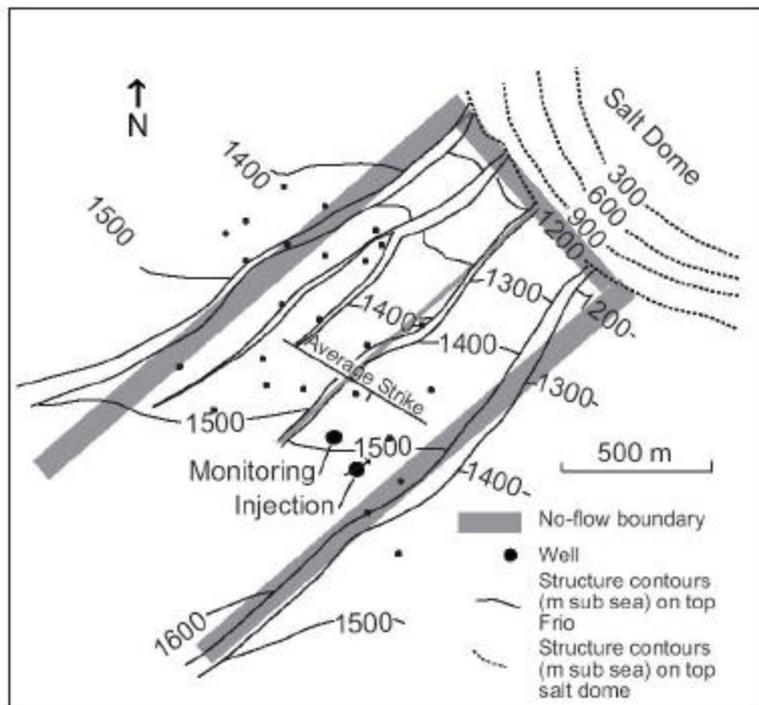
**CO<sub>2</sub> plume development for fluvial deltaic geology based on Texas Gulf Coast**

# Frio Pilot Provides Baseline Experience for Future large Scale Tests

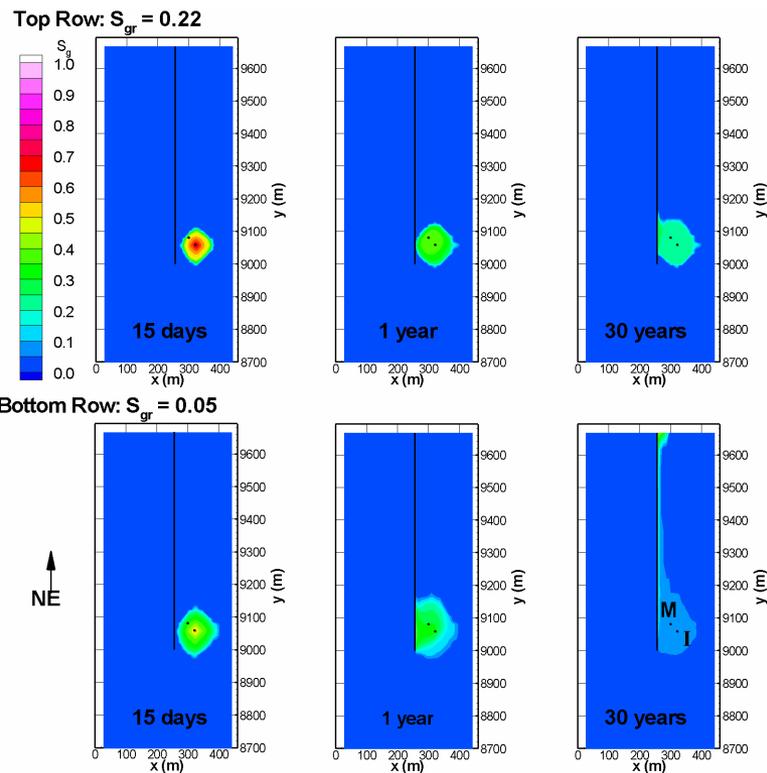
- **GEO-SEQ** working with TBEG and their private-sector partners, NETL SQUIRE, and others
- **Compartment formed by Anahuac shale and growth faults**
- **Goals include confirmation of models of CO<sub>2</sub> behavior and validation of MMV methods**



# Reservoir Simulations Guide Design of the Pilot



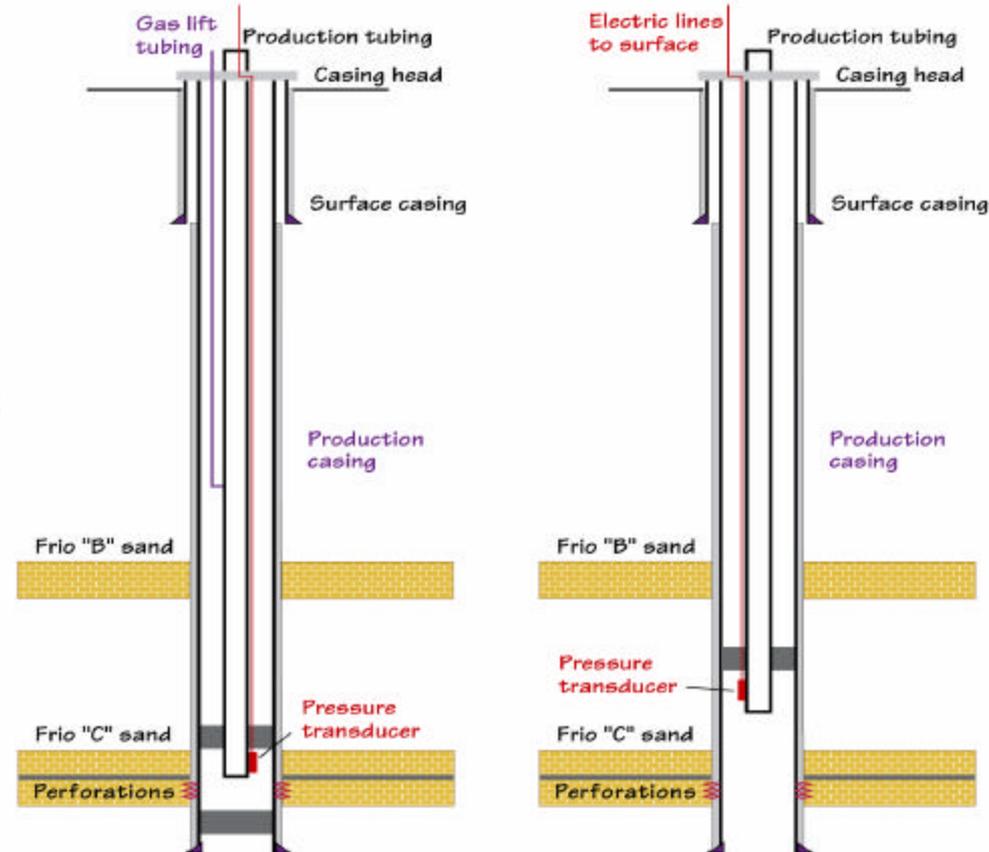
Plan view showing wells, structure and simulation boundary



Modeled gas saturation for two values of residual gas saturation

# Frio Pilot is a Testbed for MMV Techniques

- Wellbore fluid sampling
- Wellbore pressure monitoring
- Tracer (CO<sub>2</sub> isotopes, PFTs, Noble gases)
- Time lapse VSP
- Time lapse crosswell seismic
- Time lapse wireline logging
- Surface CO<sub>2</sub> monitoring



Well completions for the monitoring (left) and injection (right) wells

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# **GEO-SEQ Project Results**

**Summaries (83 pages) available on CD**

**Also see**

**<http://www-esd.lbl.gov/GEOSEQ/index.html>**